KNAPSACK CUTS AND EXPLICIT-CONSTRAINT BRANCHING FOR SOLVING INTEGER PROGRAMS

Jeffrey A. Appleget-Lieutenant Colonel, United States Army
B.S. United States Military Academy, 1979
M.S., Rensselaer Polytechnic Institute, 1989
Doctor of Philosophy in Operations Research-June 1997
Advisors: R. Kevin Wood, Department of Operations Research
Gerald G. Brown, Department of Operations Research
Alan R. Washburn, Department of Operations Research
Craig M. Rasmussen, Department of Mathematics
François Melese, Defense Resources Management Institute

Enhanced solution techniques are developed for solving integer programs (IPs) and mixed-integer programs (MIPs). Previously unsolvable problems can be solved with these new techniques. We develop knapsack cut-finding procedures for minimal cover cuts, and convert existing cut-strengthening theory into practical procedures that lift and tighten violated minimal cover valid inequalities to violated knapsack facets in polynomial time. We find a new class of knapsack cuts called "non-minimal cover cuts" and a method of lifting them called "deficit lifting." Deficit lifting enables all of these cuts to be lifted and tightened to facets as well. Extensions of these techniques enable us to find cuts for elastic knapsack constraints and cuts for non-standard knapsack constraints. We also develop the new technique of "explicit-constraint branching" (ECB). ECB enables the technique of constraint branching to be used on IPs and MIPs that do not have the structure required for known "implicit constraint branching" techniques. When these techniques are applied to 84 randomly generated generalized assignment problems, the combination of knapsack cuts and explicit-constraint branching were able to solve 100 percent of the problems in under 1000 CPU seconds. Explicit constraint branching alone solved 94 percent, and knapsack cuts solved 93 percent. Standard branch and bound alone solved only 38 percent. The benefits of these techniques are also demonstrated on some real world generalized assignment and set-partitioning problems.

A CASCADE APPROACH FOR STAIRCASE LINEAR PROGRAMS WITH AN APPLICATION TO AIR FORCE MOBILITY OPTIMIZATION

Steven F. Baker-Major, United States Air Force
B.S., United States Air Force Academy, 1981
M.S., Air Force Institute of Technology, 1991
Doctor of Philosophy in Operations Research-June 1997
Advisors: Richard E. Rosenthal, Department of Operations Research
Gerald G. Brown, Department of Operations Research
R. Kevin Wood, Department of Operations Research
Craig M. Rasmussen, Department of Mathematics
David P. Morton, University of Texas at Austin

We develop a method to approximately solve a large staircase linear program that optimizes decisions over time. Also developed is a method to bound that approximation's error. A feasible solution is derived by a *proximal cascade*, which sequentially considers overlapping subsets of the model's time periods, or other ordinally defined set. In turn, we bound the cascade's deviation from the optimal objective value by a *Lagrangian cascade* which penalizes unfeasibility by incorporating dual information provided by the proximal cascade solution. When tested on a large temporal LP developed for U.S. Air Force mobility planners, we often observe gaps between the approximation and bound of less than 10 percent, and save as much as 80 percent of the time required to solve the original problem. We also address methods to reduce the gap, including constraint extension of the *Lagrangian cascade*, as well as exploitation of dual multipliers within the proximal cascade.

DETERMINATION OF HUB FORCES AND MOMENTS OF THE RAH-46 COMANCHE HELICOPTER

William F. Beaver, Jr.-Lieutenant, United States Navy
B.A.E., Georgia Institute of Technology, 1986
Master of Science in Aeronautical Engineering-December 1996
Advisor: E. Roberts Wood, Department of Aeronautics and Astronautics
Second Reader: Donald A. Danielson, Department of Mathematics

Efforts to establish a better understanding of the performance of the RAH-66 *Comanche* helicopter were performed as part of an engineering internship with the Sikorsky Aircraft Comanche Dynamics group in Trumbull (Stratford), Connecticut. Test data from whirl stand testing and the *Comanche* Propulsion System Testbed (the ground test vehicle replacement) was evaluated. Fixed and rotating frame measurements were used to determine hub moments and forces generated by cyclic inputs. Flapping response phase to control input was also determined. Other mast loads were examined to determine the cause for greater than anticipated hub forces. Edgewise bending of the rotor blades was found to be a significant contributor to hub forces.

SIMULATION OF THE DYNAMIC BEHAVIOR OF EXPLOSION GAS BUBBLES IN A COMPRESSIBLE FLUID MEDIUM

James Earl Chisum-Lieutenant Commander, United States Navy
B.S., Southern Oregon State College, 1982
M.S., Naval Postgraduate School, 1992
Mech. Eng., Naval Postgraduate School, 1992
Doctor of Philosophy in Mechanical Engineering-December 1996
Dissertation Supervisor: Young S. Shin, Department of Mechanical Engineering
Doctoral Committee: Young S. Shin, Department of Mechanical Engineering
Anthony Healey, Department of Mechanical Engineering
Young W. Kwon, Department of Mechanical Engineering
Clyde Scandrett, Department of Mathematics
Steven R. Baker, Department of Physics

Data from one-dimensional (spherically symmetric) analyses was used to examine the effects of compressibility and gas energy on the dynamic behavior of an explosion gas bubble, by comparing the bubble's behavior with experimental results and with analytical results which neglect these factors. Results from two-dimensional (axially symmetric) analyses were used to investigate the behavior of a deep explosion gas bubble in the vicinity of plane rigid or constant pressure boundaries. Previous analytical research into explosion gas bubbles near such boundaries has primarily led to results of a qualitative nature, owing to a complete breakdown of the assumptions made in the analysis at the critical juncture. In the present investigation, it was found possible to characterize the effect of the boundary surface on both the change in the first oscillation period of the bubble and its location at the end of the first oscillation cycle. For a broad range of bubble-boundary standoff distances, these semi-empirical characterizations have a functional form particularly suitable for extension of the quantitative results of this investigation to other explosive charge types, weights, and depths, as has been done for the Willis formula for the free-field oscillation period of explosion gas bubbles.

APPROXIMATING THE CHROMATIC NUMBER OF AN ARBITRARY GRAPH USING A SUPERGRAPH HEURISTIC

Loren G. Eggen-Captain, United States Army
B.A., Saint Cloud State University, 1988
Master of Science in Applied Mathematics-June 1997
Advisor: Craig W. Rasmussen, Department of Mathematics
Second Reader: Harold M. Fredricksen, Department of Mathematics

We color the vertices of a graph *G*, so that no two adjacent vertices have the same color. We would like to do this as cheaply as possible. An efficient coloring would be very helpful in optimization models, with applications to bin packing, examination timetable construction, and resource allocations, among others. Graph coloring with the minimum number of colors is in general an NP-complete problem. However, there are several classes of graphs for which coloring is a polynomial-time problem. One such class is the chordal graphs. This thesis deals with an experimental algorithm to approximate the chromatic number of an input graph *G*. We first find a maximal edge-induced chordal subgraph *H* of *G*. We then use a completion procedure to add edges to *H*, so that the chordality is maintained, until the missing edges from *G* are restored to create a chordal supergraph *S.* The supergraph *S* can then be colored using the greedy approach in polynomial time. The graph *G* now inherits the coloring of the supergraph *S*.

MATHEMATICAL MODELING USING MICROSOFT EXCEL

Nelson L. Emmons, Jr.-Captain, United States Army
B.S., United States Military Academy, 1989
Master of Science in Applied Mathematics-June 1997
Advisor: Maurice D. Weir, Department of Mathematics
Second Reader: Bard K. Mansager, Department of Mathematics

The entry into higher mathematics begins with calculus. Rarely, however, does the calculus student recognize the full power and applications for the mathematical concepts and tools that are taught. Frank R. Giordano, Maurice D. Weir, and William P. Fox produced *A First Course in Mathematical Modeling*, a unique text designed to address this shortcoming and teach the student how to identify, formulate, and interpret the real world in mathematical terms. Mathematical modeling is the application of mathematics to explain or predict real-world behavior. Often real-world data are collected and used to verify or validate (and sometimes formulate) a hypothetical model or scenario. Inevitably, in such situations, it is desirable and necessary to have computational support available to analyze the large amounts of data. Certainly this eliminates the tedious and inefficient hand calculations necessary to validate and apply the model (assuming the calculations can even be reasonably done by hand).

The primary purpose of *Mathematical Modeling Using Microsoft Excel* is to provide instructions and examples for using the spreadsheet program Microsoft Excel to support a wide range of mathematical modeling applications. Microsoft Excel is a powerful spreadsheet program which allows the user to organize numerical data into an easy-to-follow on-screen grid of columns and rows. Our version of Excel is based on Microsoft Windows. In this text, it is not the intent to teach mathematical modeling, but rather to provide computer support for most of the modeling topics covered in *A First Course in Mathematical Modeling*. The examples given here support that text as well.

THE CONTROL OF BIFURCATIONS WITH ENGINEERING APPLICATIONS

Osa F. Fitch-Lieutenant Commander, United States Navy
M.S., Massachusetts Institute of Technology, 1982
Doctor of Philosophy in Aeronautics and Astronautics-September 1997
Dissertation Supervisor: Wei Kang, Department of Mathematics
Committee Chairman: Richard M. Howard, Department of Aeronautics and Astronautics

This dissertation develops a general method for the control of the class of local bifurcations of engineering interest, including saddle-node, transcritical, pitchfork, and Hopf bifurcations. The method is based on transforming a general affine

single-input control system into quadratic normal form through coordinate transformations and feedback. (The quadratic normal form includes the quadratic order Poincare normal form of the uncontrolled system as a natural subset.) Then, linear and quadratic state feedback control laws are developed which control the shape of the center manifold of the transformed system. It is shown that control of the center manifold allows the quadratic and cubic order terms of the center dynamics to be influenced to produce non-linear stability. Specific matrix operations necessary to transform a general affine single-input control system into quadratic normal form are provided. Specific control laws to stabilize a general system experiencing a linearly unstabilizable saddle-node, transcritical, pitchfork, or Hopf bifurcation are also provided.

A DYNAMIC TARGETING MODEL OF THE COCAINE TRADE FOR POLICY MAKERS AND INTELLIGENCE ANALYSTS (U)

Marc A. Flicker-Captain, United States Army
B.S., Pennsylvania State University, December 1986
Master of Arts in National Security Affairs-December 1996
and
Kirk H. Nilsson-Captain, United States Army
B.S., University of Idaho, May 1986
Master of Arts in National Security Affairs, December 1996
Advisors: Carlos Borges, Department of Mathematics
Gordon McCormick, Special Operations Low Intensity Conflict (SOLIC) Curriculum Committee

Our purpose in this thesis is to develop a model for use as a tool for national level policy makers. It will assist them to understand the cocaine trade, develop effective counter cocaine strategies and to make informed decisions on the allocation of resources. We created three models in the process of developing a dynamic targeting model of the cocaine trade. Our first model is a static description of the cocaine trade that explains the production, processing, and transportation of cocaine from source countries to destination countries. We used the values and spreadsheet organization derived from our static model to develop our second model, the corridor model. We use this model to generate two important values for our dynamic targeting model: Monthly estimates for how much cocaine should flow through the various corridors and from which countries this cocaine originates.

In our final model, we incorporated values from the static model and corridor model to generate a dynamic model of the cocaine system. This model allows us to evaluate various targeting scenarios over time. By evaluating various targeting scenarios, we will determine vulnerabilities and predict responses in the system over the short and long term.

COMPARING THE MAXIMUM LIKELIHOOD METHOD AND A MODIFIED MOMENT METHOD TO FIT A WEIBULL DISTRIBUTION TO AIRCRAFT ENGINE FAILURE TIME DATA

Fernando Guimil-Lieutenant Commander, Spanish Navy
B.S., Spanish Naval Academy, 1978
Licenciado Ciencias Economicas, Universidad Nacional de Educacion a Distancia, 1993
Master of Science in Operations Research-September 1997
Advisor: W. Max Woods, Department of Mathematics
Second Reader: Harold J. Larson, Department of Operations Research

This thesis provides a comparison of the accuracies of two methods for fitting a Weibull distribution to a set of aircraft engines time-between-failure data.

One method used is the Maximum Likelihood Method and assumes that these engine failure times are independent. The other method is a Modified Method of Moments procedure and uses the fact that if time to failure T has a Weibull distribution with scale parameter l and shape parameter ß, then $T^{ß}$ has an exponential distribution with scale parameter $l^{ß}$. The latter method makes no assumption about independent failure times.

A comparison is made from times that are randomly generated with a program. The program generates times in a manner that resembles the way in which engine failures occur in the real world for an engine with three subsystems. These generated operating times between failures for the same engine are not statistically independent. This comparison was extended to real data.

Although the two methods gave good fits, the Maximum Likelihood Method produced a better fit than the Modified Method of Moments. Explanations for this fact are analyzed and presented in the conclusions.

ANALYSIS OF THE NUMERICAL SOLUTION OF THE SHALLOW WATER EQUATIONS

Thomas A. Hamrick-Lieutenant, United States Navy
B.S., Economics, North Carolina State University, Raleigh, 1987
Master of Science in Applied Mathematics-September 1997
Advisor: Beny Neta, Department of Mathematics
Second Reader: Clyde Scandrett, Department of Mathematics

This thesis is concerned with the analysis of various methods for the numerical solution of the shallow water equations along with the stability of these methods. Most of the thesis is concerned with the background and formulation of the shallow water equations. The derivation of the basic equations will be given, in the primitive variable and vorticity-divergence formulation. Also the shallow water equations will be written in spherical coordinates. Two main types of methods used in approximating differential equations of this nature will be discussed. The two schemes are finite difference method (FDM) and the finite element method (FEM). After presenting the shallow water equations in several formulations, some examples will be presented. The use of the Fourier transform to find the solution of a semidiscrete analog of the shallow water equations is also demonstrated.

MARKOV RANDOM FIELD TEXTURES AND APPLICATIONS IN IMAGE PROCESSING

Christopher A. Korn-Lieutenant, United States Navy
B.S., United States Naval Academy, 1988
Master of Science in Applied Mathematics-June 1997
Advisor: Harold M. Fredricksen, Department of Mathematics
Second Reader: Carlos Borges, Department of Mathematics

In the field of image compression, transmission and reproduction, the foremost objective is to reduce the amount of information which must be transmitted. Currently the methods used to limit the amount of data which must be transmitted are compression algorithms using either lossless or lossy compression. Both of these methods start with the entire initial image and compress it using different techniques. This paper will address the use of Markov Random Field Textures in image processing. If there is a texture region in the initial image, the concept is to identify that region and match it to a suitable texture which can then be represented by a Markov random field. Then the region boundaries and the identifying parameters for the Markov texture can be transmitted in place of the initial or compressed image for that region.

PREDICTION AND GEOMETRY OF CHAOTIC TIME SERIES

Mary L. Leonardi-Captain, United States Marine Corps
B.A., Northwestern University, 1991
Master of Science in Applied Mathematics-June 1997
Advisor: Christopher L. Frenzen, Department of Mathematics
Second Reader: Phil Beaver, Department of Mathematics

This thesis examines the topic of chaotic time series. An overview of chaos, dynamical systems, and traditional approaches to time series analysis is provided, followed by an examination of the method of state space reconstruction. State space reconstruction is a nonlinear, deterministic approach whose goal is to use the immediate past behavior of the time series to reconstruct the current state of the system. The choice of delay parameter and embedding dimension are crucial to this reconstruction. Once the state space has been properly reconstructed, one can address the issue of whether apparently random data has come from a low-dimensional chaotic (deterministic) source or from a “random” process. Specific tech-

niques for making this determination include attractor reconstruction, estimation of fractal dimension and Lyapunov exponents, and short-term prediction.

If the time series data appears to be from a low-dimensional chaotic source, then one can predict the "continuation" of the data in the short term, exploiting the fact that chaotic systems are fairly predictable in the short term. This is the "inverse problem" of dynamical systems. In this thesis, the technique of local fitting is used to accomplish the prediction. Finally the issue of noisy data is treated, with the purpose of highlighting where further research may be beneficial.

AN ANNULAR THERMOACOUSTIC PRIME MOVER

Tseng-Hsiao Lin-Major, Taiwan, Republic of China Army
B.S., Chung Cheng Institute of Technology in Taiwan, 1984
M.S., Naval Postgraduate School, 1989
Doctor of Philosophy in Engineering Acoustics-September 1997
Dissertation Supervisor: Anthony A. Atchley, Department of Physics
Advisors: Thomas J. Hofler, Department of Physics
Andrés Larraza, Department of Physics
Robert M. Keolian, Department of Physics
Christopher Frenzen, Department of Mathematics
James H. Miller, Professor of Ocean Engineering, University of Rhode Island

The dissertation constitutes the first detailed theoretical and experimental investigation of a thermoacoustic prime mover with periodic boundary conditions. There are five significant aspects to this research: (1) using DeltaE to analyze an annular prime mover, (2) developing an entirely new analysis program using MATLAB, (3) designing, building, and experimentally investigating a single stack, annular prime mover, (4) experimentally investigating a constricted, single stack prime mover, and (5) predicting the performance of a two stack annular prime mover. The major conclusions are: (1) A single stack annular prime mover will not reach onset because the eigenmodes of the system do not support thermoacoustic growth, (2) A constricted annular prime mover will reach onset because the constriction forces dominating boundary conditions that alter the eigenmodes, and (3) A two stack prime mover is predicted to reach onset because one of the eigenmodes of the symmetric system does support thermoacoustics.

INTERPOLATION WEIGHTS OF ALGEBRAIC MULTIGRID

Gerald N. Miranda, Jr.-Lieutenant, United States Navy
B.A., University of California, San Diego, 1990
Master of Science in Applied Mathematics-June 1997
Advisor: Van Emden Henson, Department of Mathematics
Second Reader: Christopher L. Frenzen, Department of Mathematics

Algebraic multigrid (AMG) is a numerical method used to solve particular algebraic systems, and interest in it has risen because of its multigrid-like efficiency. Variations in methodology during the interpolation phase result in differing convergence rates. We have found that regular interpolation weight definitions are inadequate for solving certain discretized systems so an iterative approach to determine the weights will prove useful. This iterative weight definition must balance the requirement of keeping the interpolatory set of points "small" in order to reduce solver complexity while maintaining accurate interpolation to correctly represent the coarse-grid function on the fine grid. Furthermore, the weight definition process must be efficient enough to reduce setup phase costs.

We present systems involving matrices where this iterative method significantly outperforms regular AMG weight definitions. Experimental results show that the iterative weight definition does not improve the convergence rate over standard AMG when applied to M-matrices; however, the improvement becomes significant when solving certain types of complicated, non-standard algebraic equations generated by irregular operators.

AN ANALYTICAL MODEL FOR EVALUATING AEGIS MISSILE DEFENSE EFFECTIVENESS

Curt A. Renshaw-Lieutenant, United States Navy
B.S., United States Naval Academy, 1990
Master of Science in Operations Research-September 1997
Advisor: W. Max Woods, Department of Mathematics
Second Reader: Wayne P. Hughes, Department of Operations Research

The purpose of this thesis is to model the effectiveness of the Aegis combat system against supersonic anti-ship cruise missiles. The model takes into consideration the overall integration of all weapons and sensor systems on board, the availability and reliability of the weapons systems, the threat range at detection, the proficiency of the crew in employing the weapons systems, the threat range at engagement, and the probability of kill for each weapons system. This model is used to compare the effectiveness of the Aegis system operated by crews of varied proficiency with the effectiveness of the system using automated engagement systems. Additionally, a number of new, more potent weapons systems are proposed as additions to the Aegis system. An analysis of the resulting improvement in air defense capability due to the addition of these weapons and also the required level of automation for these systems is examined. The results of this analysis indicate that for certain cruise missile threats improved reaction time is more important than improved lethality for the Aegis system. Recommendations for the tactical employment of the system are given.

MODELING AND ANALYSIS OF HELICOPTER GROUND RESONANCE UTILIZING SYMBOLIC PROCESSING AND DYNAMIC SIMULATION SOFTWARE

Christopher S. Robinson-Lieutenant, United States Navy
B.S., Rensselaer Polytechnic Institute, 1989
Aeronautical and Astronautical Engineer-March 1997
Advisor: E. Roberts Wood, Department of Aeronautics and Astronautics
Second Reader: Donald Danielson, Department of Mathematics

This thesis develops a technique for formulating the full nonlinear equations of motion for a coupled rotor-fuselage system utilizing the symbolic processing software MAPLE®. The symbolic software is further utilized to automatically convert the equations of motion into C, Fortran or MATLAB® source code formatted specifically for numerical integration. The compiled source code can be accessed and numerically integrated by the dynamic simulation software SIMULINK®. SIMULINK® is utilized to generate time history plots of blade and fuselage motion. These time traces can be used to explore the effects of damping nonlinearities, structural nonlinearities, active control, individual blade control, and damper failure on ground resonance. In addition, a MATLAB® program was developed to apply the Moving Block Technique for determining modal damping of the rotor-fuselage system from the time marching solutions.

STRUCTURAL DESIGN ANALYSIS OF THE TAIL LANDING GEAR BAY AND THE VERTICAL/HORIZONTAL STABILIZERS OF THE RAH-66 COMANCHE HELICOPTER

Brian Paul Shoop-Major, United States Army
B.S., United States Military Academy, 1986
Master of Science in Aeronautical Engineering-September 1997
Advisors: E. Roberts Wood, Department of Aeronautics and Astronautics
Donald A. Danielson, Department of Mathematics
Joshua H. Gordis, Department of Mechanical Engineering

The RAH-66 Comanche's stealth design requires the use of radar-absorbing material (RAM) on the outer skin of the aircraft. The reduced stiffness properties of RAM produce insufficient tail torsional stiffness, necessitating the use of non-radar-absorbing graphite on the outer skin of the prototype's tail section. This thesis investigates structural design modifications to increase the tail section's stiffness to allow the use of RAM on the outer skin and still meet all structural requirements. An original model represents the prototype aircraft at first flight. The goal is to create a model using RAM on the

outer skin that matches the structural stiffness of the original model. This thesis builds on earlier work conducted at the Naval Postgraduate School (NPS). Two new design modifications to the tailcone are developed. The best modification increases the torsional stiffness of a baseline model by six percent. Integrating earlier NPS modifications increases torsional stiffness by 12 percent. When RAM is applied to the outer skin of the modified model, torsional stiffness is reduced by only six percent from the baseline as compared to a 24 percent reduction with no modifications. Additional modifications to the vertical and horizontal stabilizers further increase structural stiffness and reduce weight.

THE UTILITY OF HIGH RESOLUTION MODELING IN ARMY SPECIAL OPERATIONS AVIATION MISSION PLANNING

Robin R. Smith-Captain,United States Army
B.A., University of Arizona, 1982
M.Ed., Arizona State University, 1986
Master of Arts in National Security Affairs-December 1996
Advisor: Bard Mansager, Department of Mathematics
Second Reader: Maurice D. Weir, Department of Mathematics

The purpose of this thesis is to explore the application of high resolution modeling in the Army Special Operations Aviation mission planning process. This thesis looks at the unique missions Special Operations Forces are expected to perform, often at very high levels of public scrutiny, and how the use of combat simulation can assist commanders, planners and staffs in simplifying the frictions encountered in the planning process. The main objective of this study is to define common practical uses for combat simulation in deliberate and time sensitive mission planning.

This investigation surveys the use of special operations to achieve key foreign policy objectives and the ability of combat simulation to provide answers to potential questions and to stimulate queries to subjects that operators may not have considered important. By applying combat simulation in the mission planning process, planners can streamline decision-making capabilities by constructing correct and visible paths to valid conclusions. An historical case study, the raid on the Son Tay prisoner of war camp in North Vietnam in 1970, serves as a instructive example to demonstrate basic applications of combat simulation in the mission planning process and investigating variables possibly cogent to the outcome of the mission.

Finally, a discussion on high resolution special operations models used at the United States Special Operations Command and their architecture for future mission planning modeling will assist in spanning the chasm from the Cold War paradigm to new and unexpected tactical scenarios.

AN ANALYSIS OF THE DETECTION RANGE FOR THE MARK V SPECIAL OPERATIONS CRAFT USING HIGH RESOLUTION COMPUTER MODELING. (U)

Todd L. Tinsley-Lieutenant, United States Navy
B.S., University of Nebraska, Lincoln, 1989
Master of Arts in National Security Affairs-June 1997
Master of Science in Applied Mathematics-June 1997
Advisor: Bard K. Mansager, Department of Mathematics
Second Reader: Carlos F. Borges, Department of Mathematics

Naval Special Warfare (NSW) forces are designed to be difficult to detect, and not to defeat the enemy in a head-to -head confrontation. It follows that detection is a primary concern for these elite units. The latest, most versatile, high performance combatant craft introduced into the NSW Special Boat Unit (SBU) inventory to improve maritime special operations capabilities is the MARK V Special Operations Craft (MK V SOC). The role of this craft is for medium range insertion and extraction of special operations forces (SOF) in a low to medium threat environment. This thesis uses a high resolution computer simulation model, Janus, to represent the characteristics and operating parameters of the MK V SOC along with three, electro-optical night vision devices (NVD). Through repeated computer simulation runs, detections of the MK V SOC by these sensors in three varying meteorological conditions is tested. The range to first detection is recorded for each

case and analyzed using graphical and statistical methods. Based on the sample data of detection ranges, statistical inferences are made about a sensor's performance under prescribed environmental conditions and its ability to detect an approaching MK V SOC.

ANALYSIS OF POTENTIAL STRUCTURAL DESIGN MODIFICATIONS FOR THE TAIL SECTION OF THE RAH-46 COMANCHE HELICOPTER

Vincent M. Tobin-Major, United States Army
B.S., Bucknell University, 1985
Master of Science in Aeronautical Engineering-June 1997
Advisors: E. Roberts Wood, Department of Aeronautics and Astronautics
Donald A. Danielson, Department of Mathematics
Joshua H. Gordis, Department of Mechanical Engineering

The Army RAH-66 Comanche Helicopter made its first flight in January of 1996. Its current structural configuration, however, does not meet the Army's requirements for radar signature. Structural configurations of the tailcone that meet radar cross-section requirements tend to lack sufficient structural stiffness due to the presence of Kevlar in place of graphite on the outer mold line. This thesis investigates potential structural design modifications to the Comanche tailcone that would move the design closer to meeting both its structural and radar signature requirements. Structural geometry modifications with baseline (current configuration) materials increased torsional stiffness by six percent. Geometry modifications using radar signature-compliant materials reduced torsional stiffness by 15 percent. The geometry changes analyzed produce structural performance improvements insufficient to allow the use of radar-compliant materials without further geometry changes.

HIGH RESOLUTION MODELING OF SOF MINE-COUNTERMEASURE OPERATIONS (U)

Robert C. Wilson-Lieutenant Commander, United States Navy
B.A., College of the Holy Cross, 1986
Master of Arts in National Security Affairs-March 1997
Advisor: Bard K. Mansager, Department of Mathematics
Second Reader: Maurice D. Weir, Department of Mathematics

This thesis explores ways in which stochastic high-resolution modeling may be utilized by maritime special operations forces (SOF) as a tool for tactics development and mission planning. Using SOF mine countermeasure (MCM) operations for illustrative purposes, the study focuses on testing and evaluation of the Janus high-resolution model (HRM). Model development includes terrain, amphibious minefields, enemy shore-based surveillance systems, SOF MCM units, and tactics pertinent to SOF mine reconnaissance operations. Model execution tests three SOF MCM search tactics in minefields laid according to enemy doctrine. Following multiple iterations, sensitivity analysis is conducted on search tactics and various surface support craft detection vulnerabilities.

Study findings demonstrate HRM utility for optimization of tactics and model-assisted mission planning. The model developed in this study may augment ongoing maritime craft detection vulnerability studies. Model development, testing, and analysis reveals shortfalls and limitations pertaining to the model and databases used. The study provides recommendations for the improvement of future high-resolution models that include maritime SOF operations. Recommendations may be applicable to Janus derivative models such as the Joint Tactical Simulation (JTS) and Joint Conflict Model (JCM).